



RCA

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Technical Lesson 57

SPARK TRANSMISSION

The energy required to produce electromagnetic waves for wireless telegraph purposes was at one time obtained by the use of an induction coil. The waves radiated from such a device, however, were weak and, at the best, only comparatively short distances could be covered. Alternating current generators, because of their power and economical operation, very soon supplanted the induction coil for radio telegraphic work. Before proceeding further with the lesson, a brief review relative to some of the contributing sources in the progress of wireless communication should be interesting.

Steinheil, of Bavaria, was the first to utilize the earth as one conductor of an electrical circuit and the first to successfully transmit electricity without a wire return. This occurred in the year 1838. However, prior to this date, Faraday made the important discovery that the phenomenon of electromagnetic induction existed between two entirely separate circuits.

There were experiments involving the phenomenon of electromagnetic induction conducted by several scientists without any developments of commercial value until 1678, when Huygens, a Dutch mathematician, conceived the hypothesis that all space not taken up by matter was permeated by a substance which he termed "ether", and by which he accounted for the phenomenon of light. Faraday, who was a great believer in this hypothesis, demonstrated in 1845 that electric and magnetic forces were propagated through the same medium.

In 1867 Clark Maxwell came forth with the laws of electromagnetism. He more fully developed these laws in 1873 at which time he predicted the electric wave we are now so familiar with in radio telegraphy and telephony.

In 1880 Professor Trowbridge of Harvard University determined that signalling was possible by electric conduction through the earth, or through water, and in 1882 experiments carried out by Alexander Graham Bell under the Trowbridge idea resulted in the detection of signals through water for the great distance of $1\frac{1}{2}$ miles.

The next important link in the development of radio was closed by Hertz, a German scientist, who, in working on prior fundamental theories laid down by Faraday and Maxwell, actually produced electromagnetic waves which followed all the known laws of light waves. The apparatus used by Hertz appeared somewhat as shown in Figure 1. This transmitting apparatus consisted of an induction coil which was energized by a battery. The high voltage terminals of the secondary winding of this coil were connected to what was termed an "oscillator", formed by two brass spheres "SS" attached to large metal sheets by the connecting brass rods "BB", and it was by this arrangement that electric waves were radiated.

The Hertz receiver was simply a loop of wire with the ends brought close together, the space between the ends of the wire forming the spark gap "G" as shown in Figure 2. With this apparatus Hertz had complete equipment for transmitting and receiving electric waves. When he energized the induction coil a spark jumped the air gap between the spheres "SS." On the other side of the experimental room he suspended his ring of wire (receiver). The oscillating waves produced by his transmitter travelled through space at a speed of 186,000 miles per second and, sweeping by the ring receiver, induced sufficient electromotive force in it to cause a spark to jump this gap also. In this way the Maxwell theory was proved and thus transmission of signals through space without the use of metallic conductors was begun. Many improvements were necessary, however, before an efficient system could be de-

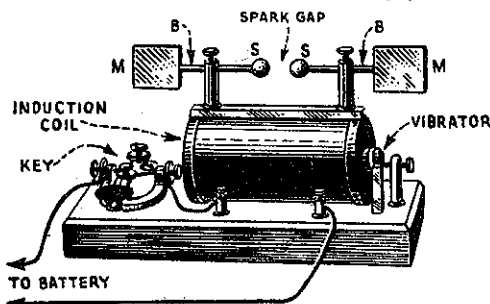


Figure 1

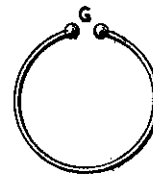


Figure 2

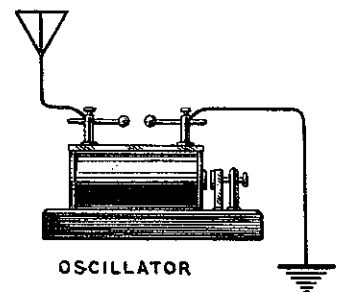


Figure 3

vised that would operate successfully on a commercial scale. The Hertz receiver, for example, required so much energy that the affects were noticed only at short distances.

In 1879 Hughes discovered that loose metallic filings would "cohere", that is, stick and hold firmly together when an electric spark was discharged in the vicinity. This led to the introduction of the device known as the "coherer", developed in 1892 by Professor Branly of Paris. Branly filled a small glass tube with iron filings and stopped each end of the tube with metal plugs to which he connected leads from the receiving circuit. This device was used to detect the presence of Hertzian waves. In its original form the coherer was useful only in detecting the very start of the electric wave, (Hertzian wave) for at the first spark the metallic particles would stick together and ruin its properties as a detector.

Popoff, a Russian scientist, using the coherer idea to study atmospheric electricity, made a brilliant contribution to the wireless development by combining an electric bell with the Branly coherer. He utilized the hammer of the bell to lightly tap the glass tube containing the filings. This was a wonderful advance for it made possible the measurement of the Hertzian wave. This improvement was named the "decoherer."

It was at this time that Marconi, barely out of his 'teens, began his experiments with a bold vision of linking the entire world together by means of wireless telegraphy. (And nothing need be said of how well his vision has been realized). In the course of his experiments, which was with the Hertz oscillator, he made the discovery that when one side of the spark gap was

connected to earth, and the other connected to a wire suspended in the air, the electric waves travelled a much greater distance than those produced by the Hertz oscillator in its original form. Refer to Figure 3. The Marconi receiver was similar to the receiver used by Popoff, but embodied many improvements in constructional design.

The year 1896 saw wireless communication carried on by Marconi for a distance of $1\frac{3}{4}$ miles and, due to improvements, he increased this distance to 18 miles one year later. In 1902 he succeeded in spanning the Atlantic ocean; a remarkable achievement at that time.

The imagination does not have to be stretched to realize that communication by wireless was not the result of one man's work, nor was it accomplished over night. Rather it is the result of work by many men over a long period of time. From 1902, however, rapid advancement was made in wireless communication; wireless had ceased to be a laboratory plaything; it had passed into the commercial world and was ready for practical use.

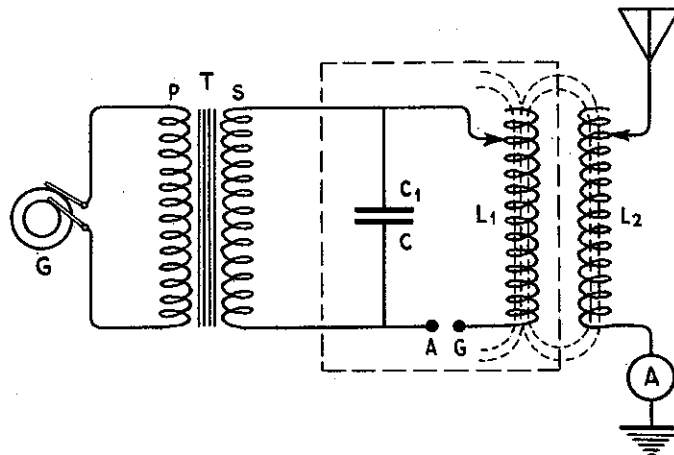


Figure 4

Ocean-going ships were soon provided with sending and receiving apparatus which enabled them to exchange messages with land. The apparatus at this time was still in the form of an induction coil; the primary winding was excited by an alternator instead of a battery. Further improvements were made in spark transmission apparatus, and it is the object of this lesson to bring to the student a working knowledge of the apparatus he may be called upon to operate.

As stated in the first part of the lesson, the generator is a more economical way to produce electric waves, and since the average power required is 2K.W. the generators usually have a rating of 100 volts, and 500 cycles. The apparatus required for generating high frequencies is shown in Figure 4. It consists of an alternating current generator "G" and a step up transformer "T," which receives current in the primary "P" at a pressure of 110 volts, and steps it up to 20,000 volts in the secondary "S." The high voltage is then fed into the condenser "C," which stores it up until there is sufficient

pressure to break down the air gap "AG". When this takes place the condenser discharges across the gap, the spark providing a path for the current to flow which, upon leaving the condenser, passes across the gap through inductance coil L_1 , called the closed circuit oscillation transformer. The current now flows back into the condenser at C_1 , thus charging the condenser to the opposite polarity; it immediately discharges, this time in the reverse direction. As a result of the current passing through coil L_1 , lines of force are set up which thread through and induce current in coil L_2 . This part of the circuit is called the "secondary" or "open circuit" of the oscillation transformer and, since the antenna is connected to this coil, energy in the form of electromagnetic waves is radiated through space.

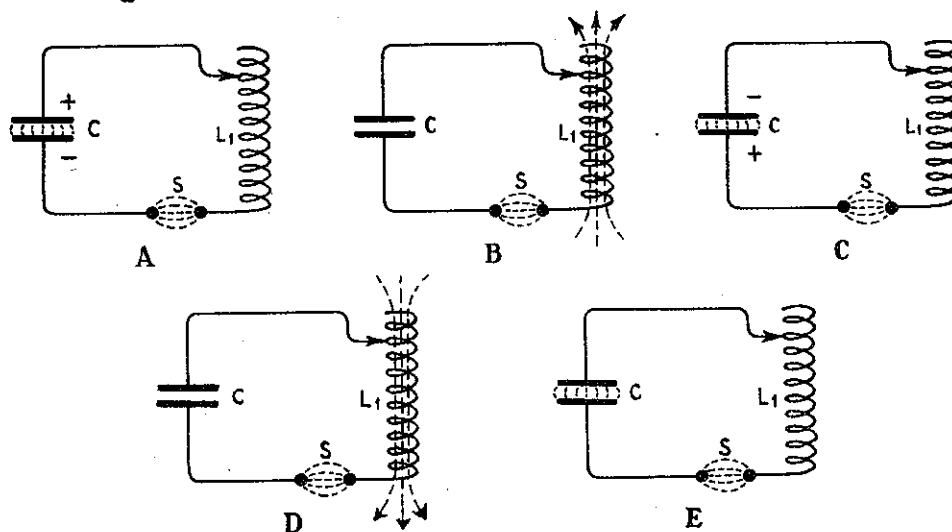


Figure 5

Analysis of the Spark Discharge. In order to study the spark discharge created by a condenser we will isolate that part of the fundamental diagram shown within the dotted lines of Figure 4 and study it from Figure 5. Just previous to the first discharge the charge in the condenser takes the form of an electrostatic field which is stored up between the plates as in Figure 5A. The strain is such that a spark leaps from the positive electrode to the negative electrode of the gap; that is, the collapse of the electrostatic field causes a current to flow across the spark gap through the inductance L_1 , which sets up a magnetic field around the coil L_1 and connecting leads as in Figure 5B. Since all of the electrostatic field is converted to current, the magnetic lines of force collapse back upon the coil L_1 (and connecting leads); the induced current resulting there-from recharging the condenser to the opposite polarity as in Figure 5C. Although charged in the opposite sense, a quantity of electricity less than that of the initial charge is stored between the plates, some of the energy having been expended by the resistance of the circuit and the production of heat, light and sound. The condenser now discharges across the spark gap in the direction opposite to that indicated in Figure 5B and the coil L_1 once more is surrounded by a field, Figure 5D, but which is opposite in polarity to that of Figure 5B. These lines of force collapse and recharge the condenser to the polarity indicated at the beginning of the cycle in Figure 5E, but a charge less in quantity is stored between its plates than at the beginning of discharge.

All this may be summed up by saying that when an isolated charge of electricity is applied to a condenser, and the plates are connected together by an external circuit, their charges do not completely neutralize at the first instant of discharge but, in fact, several alternations of current take place before equilibrium is restored. This gradual extraction of energy from the oscillations set up by the condenser is termed the "damping of the oscillations" and the decrease in amplitude of the successive cycles can be expressed in a logarithmic percentage.

The number of oscillations taking place across the spark gap can be varied to a considerable extent by adjusting the number of turns in the closed circuit oscillation transformer L_1 , and adjusting the length of the spark gap. When the adjustments are such that the oscillations occurring at each discharge have the shape and appearance of Figure 6 they are said to be "excessively damped," that is, they die out very rapidly. The transmitter is then said to be very broadly tuned and will radiate a very broad interfering signal.

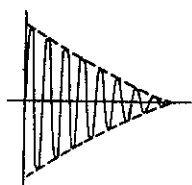


Figure 6

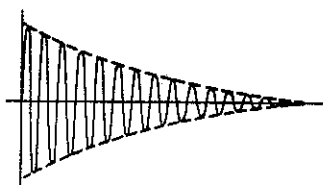


Figure 7

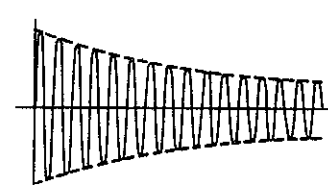


Figure 8

Figure 7 shows highly damped oscillations while Figure 8 illustrates oscillations of a feebly damped character. When adjustments are made in a spark transmitter so that the conditions of damping shown in Figure 8 extend and apply to the secondary, or open oscillating circuit L_2 , Figure 4, the energy of the radiated wave is largely confined to a single frequency and the effect at the receiver is called "sharp tuning." A sharply tuned wave requires very careful adjustment of a distant receiver in order to place the receiving apparatus in resonance with the transmitted signal wave.

It is natural that an operator would not desire to receive signals under conditions where a transmitter was emitting a wave of excessive damping for the reason that such a transmitted wave would "blanket" other signals. Under such a condition all the adjustments he could possibly make with his receiver controls would not result in tuning out the broad wave thus radiated. It is very clear then, that a transmitter must not radiate a broad wave, i.e., one in which the oscillations of each spark discharge die rapidly to zero.

Now going to the other extreme, it is equally undesirable when working with spark transmission to have a transmitter so adjusted that the wave is "feebly damped." In operator's parlance, such a wave would be "extremely sharp," and it would require considerable skill and patience to adjust the receiver controls to hear and actually copy the signal. Therefore, a compromise must be affected between these two extremes whereby it will not be either an extremely broad nor an extremely sharp wave but will be somewhere between the two.

It is interesting to know just how this condition can be realized, but in the explanation a new term will have to be introduced, which is "Logarithmic Decrement." It will be also necessary to review our study of the word, "Oscillation" and "Amplitude."

Each time a spark discharge takes place across the gap "AG," Figure 4, energy is radiated from the antenna in the form of wave trains, each train being made up of a number of oscillations which decrease in amplitude at each successive oscillation. Each of these oscillations is assumed to decrease in

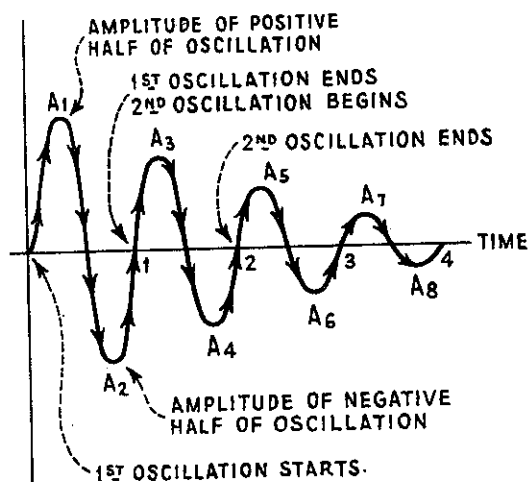


Figure 9

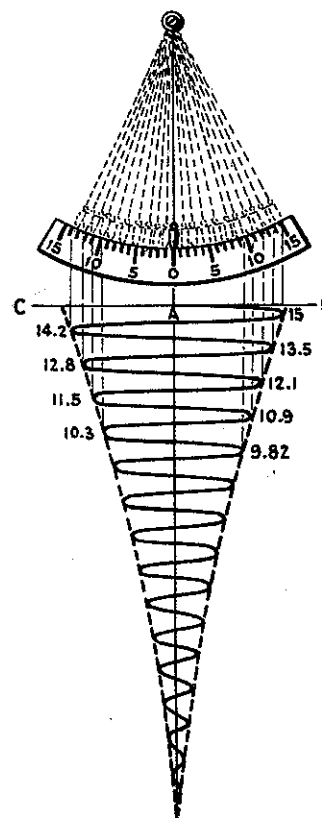


Figure 10

amplitude according to the law that the ratio of any oscillation to the one preceding or following it is constant. To make this clear, let us refer to Figure 9. Here we see one wave train consisting of four complete oscillations. The amplitude A_1 , the first, being the most intense, that is, having the greatest value, and all the following ones showing a steadily decreasing value until they die away to zero. We said, however, that the ratio of any oscillation to the one preceding it was constant. If this is so let A_1, A_2, A_3 , etc., represent the maximum amplitudes of successive alternations. Then, according to the above statement, and beginning with A_1 , a definite relationship of decrease will exist between the amplitudes of all the following successive alternations of each oscillation. We may then say that the decrease in amplitude A_1 is to the decrease in amplitude A_3 , as the decrease in amplitude A_3 is to the decrease in amplitude A_5 , and as the decrease in A_5 , is to decrease in amplitude A_7 , and so on, to the end of the wave train.

This constant ratio of decrease in amplitude of each succeeding alternation is called the "damping" of the oscillations, and the decreasing ratio of one oscillation to the following is called the "logarithmic decrement." The exact meaning of the logarithmic decrement of the oscillations in radio-telegraphy may be better understood by considering the oscillating movements of a pendulum in mechanics. Suppose for example, a plumb bob is attached to the end of a string and suspended freely as in Figure 10. Drawn to one side, and released, the bob will vibrate to and fro until the oscillation is completely damped out. If a piece of cardboard, for instance, were attached to the string, the oscillations of the pendulum would come to a stop in a much shorter period; they would be said to be highly damped. This corresponds to the damping of the oscillations in a radio oscillation circuit having considerable resistance. Now the time period of one complete oscillation of the pendulum can be obtained by counting the oscillations for one minute and dividing their number by 60. Hence if 60 complete oscillations took place per minute, the time period of one oscillation would be one second. This could be easily arranged if the string of the pendulum had a certain length and the bob a certain weight.

Assume that the bob is oscillating in front of a scale calibrated in inches as in Figure 10 and that at the beginning of the first oscillation it was drawn from the zero position outward to a distance of 15 inches. On account of wind friction, at the end of one-half oscillation the bob would not have travelled 15 inches from the zero position. Under suitable conditions it would move outward, let us say, 14.2 inches and in the return swing, its second oscillation would be $1\frac{1}{2}$ inches less than the initial oscillation. If we observe the length of the successive swings and plot the results as in Figure 11 we would obtain a group of decaying oscillations which would bear the following ratio to one another. If the horizontal axis A, B, is divided into seconds, and the amplitude of the right and left swings of the pendulum shown by the notations on the vertical axis, (0 to 15, in either direction) then the amplitude at the termination of a complete period or at any partial period of oscillation will be as follows: At the end of the first half period, the amplitude of the oscillation will be 14.2; at the end of a complete period, 13.5. After the pendulum has been in oscillation for $1\frac{1}{2}$ seconds, the amplitude will be 12.8 and at the end of two seconds, 12.1 and so on.

It is to be especially noted that the ratio of the amplitude of the successive oscillations is constant; that is $15 \div 13.5 = 1.11$; $13.5 \div 12.1 = 1.11$, and so on. This ratio will be constant to the end of the swings of the pendulum because it is a law of all mechanical oscillating motions that the oscillations will die away at such rates that the ratio of successive amplitudes remains constant. This is the condition assumed to exist in the spark discharge circuits of radio transmitters.

It should be clear from the foregoing that if the friction (resistance) to the oscillations of the pendulum in Figure 10 were increased by attaching a piece of cardboard to the pendulum to dampen its movement, the to and fro swings would die out more rapidly and the ratio of the successive amplitudes would become greater, that is, the damping of the oscillations would be in-

creased. From this we learn that slow damping corresponds to a great number of swings of the pendulum, while rapid damping corresponds to a small number of swings of the pendulum.

Now, in a spark transmitter the damping of the electrical oscillations can be made slow by connecting in more turns of wire on the oscillation transformer which corresponds to the damping principle just explained; i.e., of adding resistance to the circuit, or rapid damping can be accomplished by reducing the resistance of the circuit. The tuning qualities of a train of electric waves from a given transmitter depends greatly upon the decrement of the oscillations and, therefore, this is an important factor.

An ideal condition in spark transmission is realized by adjusting the closed and open oscillation circuits of a spark transmitter (L_1 and L_2 of Figure 4) in such a manner that for every spark discharge each wave train is found to consist of exactly 24 complete oscillations.

It is also found that less than 24 complete oscillations per spark discharge will tend toward a broad interfering wave, and more than 24 will require sharp tuning in the receiver.

Because of the foregoing a U. S. law was made to the effect that a decrement of 0.2 must be maintained by spark transmitters; this decrement is possible when 24 complete oscillations occur for each spark discharge. All of this means that if the oscillations in a given antenna circuit have a decrement of 0.2 the logarithm of the ratio of A_1 to A_3 will be 0.2, and the number corresponding to the logarithm of 0.2 is 1.2, therefore in actual radio practice the ratio of amplitudes A_1 to A_3 of Figure 9 must be 1.2 for a decrement of 0.2 required by U. S. law.

Resonance. The condition of electrical resonance was discussed in Lesson 25. This phenomenon is very striking in radio frequency circuits. It is desirable in radio transmission to adjust the circuits L_1 and L_2 , Figure 4, in such manner that the most effective transfer of electromagnetic induction takes place between the two circuits. Circuits for demonstrating the phenomenon of resonance appear in Figure 11. Two circuits of radio frequency LCG and L_1 , C_1 , A , are magnetically coupled at the coils L and L_1 . If circuit LCG is set into oscillation and circuit L_1 , C_1 , A , carefully adjusted by varying the number of turns used in L_1 , or by varying the capacity C_1 , a point will be found where the hot wire ammeter "A" will give a maximum deflection and at all other point of adjustment the ammeter will show a lower reading. From this we learn that the adjustment of the second circuit where the deflection of the ammeter is maximum, is such that the two circuits have substantially the same period of oscillation, or in other words, the same natural frequency. It is under these adjustments only that large values of current can be induced in the circuit L_1 , C_1 , A .

The Length of Electromagnetic Waves. The standard wavelengths for spark transmission are as follows: 600, 706, 750, 800, and 900 meters. To calculate the approximate wavelength two factors must be known. First, the number of complete waves passing a given point in one second of time, and second, the

speed that electromagnetic waves travel. As an example, assume that 1,000,000 complete waves pass in one second. The speed they travel is the same as the speed of light waves, or 186,000 miles in one second. Measured in meters it is 300,000,000 meters. A 300 meter wavelength then would be equal to 300,000,000 divided by 1,000,000. The wavelength may also be found if the inductance and capacity of the antenna are known. Without going into higher mathematics a very practical solution which gives a good working approximation of the result is as follows: Suppose you have a single wire antenna and you want to know its natural wavelength. All you have to do is add the flat or horizontal length to the length of the lead-in, plus the length from the set to ground, and multiply this sum by 1.5. For example, the antenna shown in Figure 12 has the dimensions given, $75 + 20 + 10 = 105$ feet, total. $105 \times 1.5 = 157.5$ meters, the natural wavelength of the antenna.

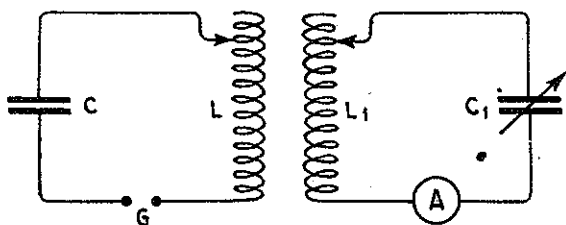


Figure 11

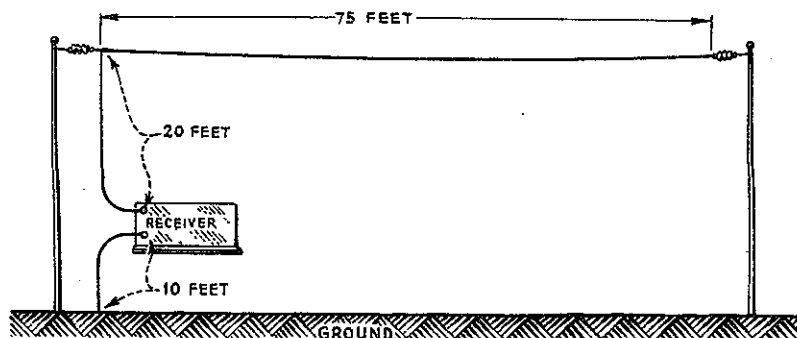


Figure 12

On ship board a different condition exists. Here the quick method of approximating the natural wavelength of a four wire aerial with the wires spaced $2\frac{1}{2}$ feet apart is 4.4 times the total length of the antenna in meters from the far end of the aerial to the set. As an example of calculating the approximate wavelength of a ship aerial 225 feet in length, we reduce feet to meters (1 foot = 0.3048 meters) and multiply by 4.4:

$$225 \times 0.3048 = 68.58 \text{ meters}$$

$$68.58 \times 4.4 = 301.75 \text{ approximate wavelength.}$$

The values 1.5 and 4.4 are called "constants" and are arrived at by actually conducted experiments. A measurement of this nature brings out an important point. It shows that the electromagnetic waves radiated from an antenna can be varied, that is, shortened or lengthened by simply changing the length of the antenna. In practice this is done by means of an inductance, called a "tuning coil," which is connected in series with the antenna. By tapping the coil at different points more wire may be connected in or taken out of the circuit.

Antenna Resistance. As explained in Lesson 25 the resistance in an oscillatory circuit must be small. We are now discussing such a circuit and the antenna and coils connected in series with it. It was stated in Lesson 25 that if the resistance of an oscillatory circuit is greater than the square root of the inductance divided by the capacity and this result multiplied by two, $2 \sqrt{L/C}$, the circuit will not oscillate on the discharge of the condensers across the air gap. (The resistance of the air gap is not considered in the calculation.) This tells us that to make a good oscillatory

circuit of an antenna the resistance must be kept as low as possible. In practice this is accomplished by using large phosphor bronze aerial wire and providing good ground connections thereby keeping the antenna resistance at a minimum.

Producing Oscillations in the Antenna. The conductive (direct) method of producing oscillations in an aerial is shown in Figure 13. The advantage of this method lies in its simplicity of connections. It also has the very great disadvantage in the fact that the oscillations produced are rapidly damped out and the waves radiated will be broad and thereby interfere with signals from other stations. A great strain is also placed on the antenna insulation when this method of coupling is employed. The conductive method of exciting oscillations in the antenna are therefore never used except when a powerful and broad interfering wave is desired, as for instance, in the case of an SOS.

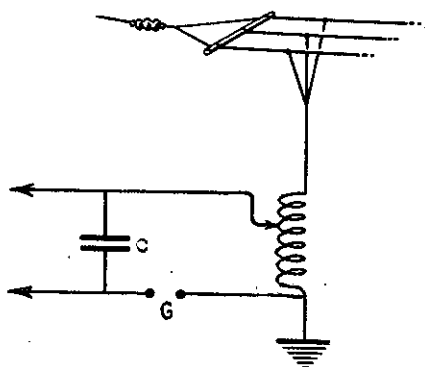


Figure 13

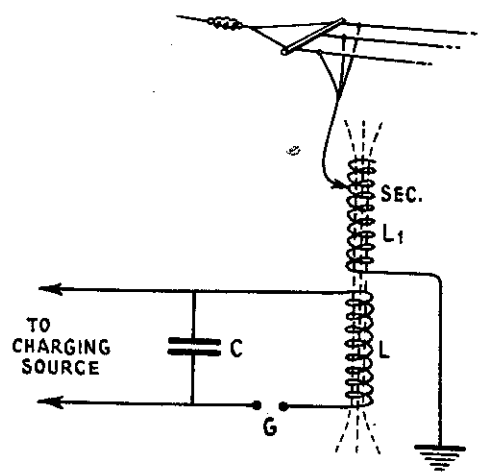


Figure 14

The inductively coupled method, Figure 14, is the manner employed to excite all present day spark transmitters. In fact the direct coupled method just spoken of is prohibited by law, hence the inductive method is almost entirely used. The advantages of producing oscillations in an antenna in this manner lies in the fact that the closed circuit condenser "C" acts as a reservoir of energy, and since the capacity of the condenser in the closed oscillation circuit is generally several times that of the capacity of the aerial, it permits the closed circuit to use large amounts of power for the same wavelength. The spark gap "G" is placed in the closed circuit CGL. The oscillations generated in this circuit are transferred to the open oscillation circuit L_1 , where they are radiated from the antenna in the form of electromagnetic waves.

How Wavelength is Changed. Because of the different classes of traffic in radio telegraphic service the transmitting apparatus must be capable of being changed easily with respect to the length of the radiated wave produced. An example of how this is carried out is shown in Figure 15 where the wavelength is being shifted from 900 to 600 meters. The clip is shifted on coil L_1 to the position shown by the dotted lines, indicating that turns have

been cut out of this coil. Clip No. 2 is moved upward on coil L_3 (the antenna tuning coil) also cutting turns out of this coil.

Various Types of Antennas.- Five general types of aerials are in use:

- (1) The vertical or fan aerial;
- (2) The umbrella aerial;
- (3) The inverted "L" flat top aerial;
- (4) The "T" aerial;
- (5) The "Cage" aerial.

(1) The vertical aerial shown in Figure 16 consists of a fan or harp of copper or silicon bronze wires held vertically into space by a wooden mast, a steel tower, or any convenient structure of sufficient height. The wires of the harp may or may not be joined at the top. All wires, however, must converge at the lower end where they enter the station house and are connected to the apparatus. The free end of the vertical aerial must be well insulated to prevent direct leakage to the supporting halyards or stays, and at the lower end the wires must be stayed to take the strain off the station house roof insulator.

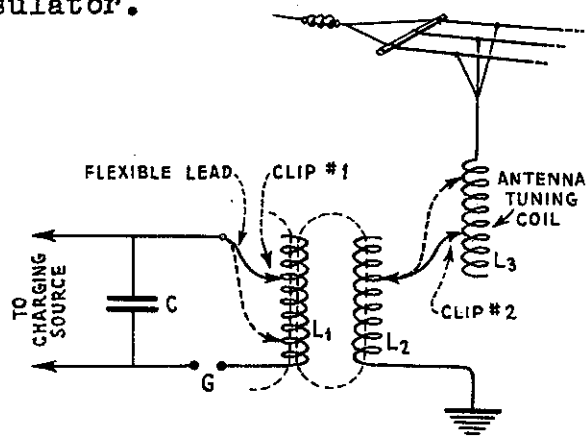


Figure 15

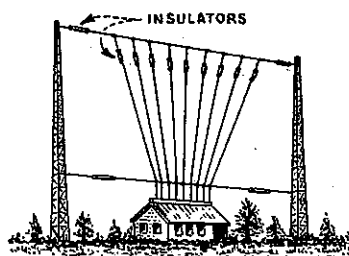


Figure 16

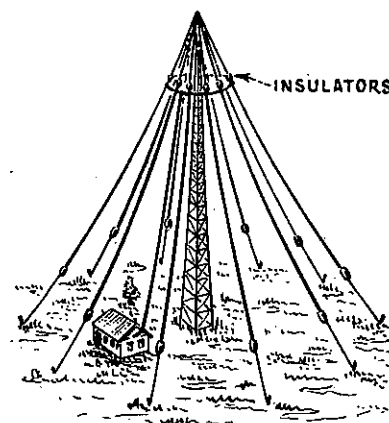


Figure 17

Although the vertical aerial is acknowledged to be the best radiator of electromagnetic waves practically equal results can be obtained from a flat top aerial (of increased dimensions) with a less expensive supporting structure. Irrespective of the degree of efficiency obtained, a vertical aerial could not possibly be used aboard vessels on account of the derrick booms, mast guys and smoke funnels which take up the space that would be required for erection.

(2) The umbrella aerial shown in Figure 17 receives its name from its general shape and similarity to an umbrella. It will be noted in this diagram that a number of wires spread radially in several directions from a common center at the top of the mast, and that a wire extends therefrom to the apparatus in the station house. The ribs of the umbrella generally are about two-thirds the length of the mast, but the guying out wires must be six to seven times the length of the vertical part. Although it has been found to be of some value for portable military sets, the umbrella aerial is scarcely employed in commercial practice.

(3) The inverted "L" flat top aerial on Figure 18 is most commonly employed for ship service and quite extensively in broadcasting. It consists of a number of parallel wires stretched between two masts and attached on either end to wooden or metal spreaders, which are thoroughly insulated from the supporting halyards. The horizontal wires A to B are called the "flat top portion" and the vertical wires, the "lead-ins".

The lead-in wires, which should have equal conductivity to the wires in the flat top, are attached to one end of the horizontal wires, then passed through a deck insulator and finally connected to the apparatus within the station. The flat tops of the majority of ships vary from 75 to 250 feet in length and the lead-ins from 70 to 150 feet.

If the lead-ins are attached to the center of the flat top, as in Figure 19, the aerial is said to be of the "T" type.

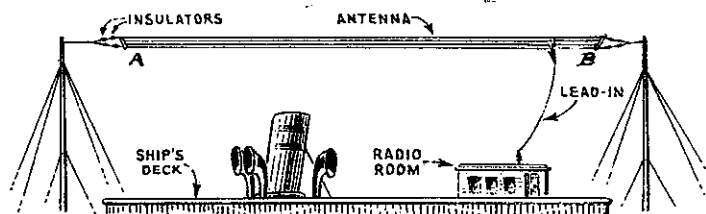


Figure 18

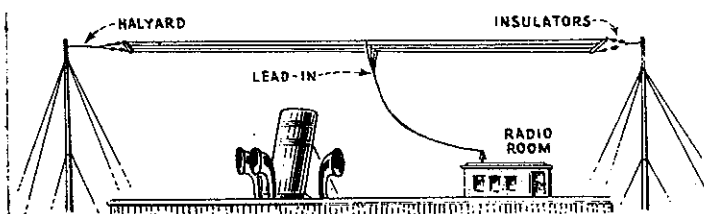


Figure 19

Either "T" or "L" aeriels are most suited to merchant vessels, principally because they are more convenient to install. They generally have 2, 4 or 6 wires; the majority, however, have four wires spaced from $2\frac{1}{2}$ to $3\frac{1}{2}$ feet.

The fundamental wavelength of the "T" aerial is invariably less than that of the inverted "L" type of the same dimensions. When the lead-ins of a given aerial are removed from the end of the flat top and attached to the center, the total inductance will be less than with the previous connection, and since by this change the capacity of the system remains practically unchanged, the length of the radiated wave will be less than in the case of the "L" aerial. This is easily understood if considered in the following manner: Beginning at the point where the lead-ins are attached, the two ends of the flat top may be considered as two aeriels in parallel, and, as is well known, the inductance of two parallel conductors is less than that of either taken separately; therefore, the total inductance of the antenna will be reduced and the radiated wave reduced accordingly.

To illustrate the point: A four-wire inverted L type of aerial, 100 feet in length, 60 feet in height, has capacity of .0004 microfarads, and inductance of 62,000 centimeters. A "T" aerial of the same dimensions has capacity of .0004 microfarads, and inductance of 37,000 centimeters. Keeping in mind the simple formula ($\lambda = 38 \times \sqrt{LC}$) for computing the wavelength of a radiative oscillator, the change in wavelength brought about by this connection is easily determined. The wavelength of the "L" aerial will be approximately 188 meters and the "T" aerial, approximately 145 meters.

(5) The cage antenna is rapidly becoming popular in the amateur transmission field and it is also used by a few broadcasting stations. It has been adopted

in commercial radio service on a large number of foreign vessels but is not generally employed on American ships. Its principle of current radiation is, of course, the same as other flat top aeralis. The high frequency currents flowing along a multi-wire flat top aeral have a tendency to "edge" toward the outside wires, with the result that these outside wires carry more than their part of the current thereby increasing the resistance of this portion of antenna. However, although this increased resistance is not of great importance, its effect is entirely eliminated in the cage type antenna as all wires are outside wires, as shown in Figure 20. The low resistance of the cage, while it has less capacity than the ordinary flat top, makes it preferable in many cases.

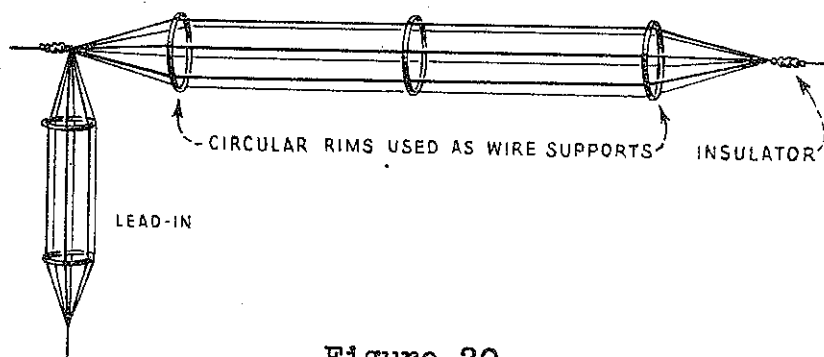


Figure 20

We may sum up the advantages or disadvantages of the various types of aeralis briefly, as follows: The vertical aeral is a very efficient radiator of electric waves; but if large amounts of energy are to be radiated, a large aeral and a very high supporting structure are required; the cost of the latter may be prohibitive. The umbrella aeral does not quite possess the radiating properties of the vertical aeral and due to the fact that the ribs of the umbrella must be guyed out several hundred feet from the base of the supporting mast, a large area is required for its erection. But with this disadvantage, the umbrella aeral is found to be of some value in portable military stations, where the ribs of the aeral act as guy supports as well as radiators of the electric waves.

The "L" and "T" aeralis also do not radiate quite as efficiently as the simple vertical aeral of the same dimensions, but they have slightly lower natural decrements, and therefore, radiate a sharp wave with less localized inductance. Flat top aeralis can be erected more economically than vertical aeralis of much shorter length and they prove to be just as effective at less initial expense. Over all, it must be kept in mind that irrespective of the degree of efficiency obtained, the flat top aeral only can be conveniently employed aboard ship. Cage aeralis are considered flat top.

Standard Transmitting Aeral. Now that the fundamental design of the various aeralis has been shown, the construction of a standard ship's aeral (Radio Marine Corporation) will be described in detail. It will be noted from the diagram of Figure 21 that the flat top contains six silicon bronze wires, each containing 7 strands, No. 18 wire. The wires are preferably equally spaced and are attached to spruce spreaders from 14 to 18 feet in length which in turn are attached to the running halyards by a bridle which is made up of strop insulators. These insulators consist of 5/8 inch Russian boat rope which is partly covered by a hard rubber tube. The space between the tube and

the rope is filled with hot sulphur which when cold, hardens and keeps out moisture. Both ends of the bridle terminate in a heart-shaped shackle to which a galvanized steel halyard wire for raising and lowering the aerial is attached.

To prevent the spreaders from swaying, side stays are attached to the ends (of the spreader) and fastened to the mast. Twenty-four-inch hard rubber rod insulators are inserted in the rope to prevent leakage of the current in wet weather. It will be seen also that each wire of the aerial is insulated by a 2-foot hard rubber rod which is attached to the spreader by an eyebolt.

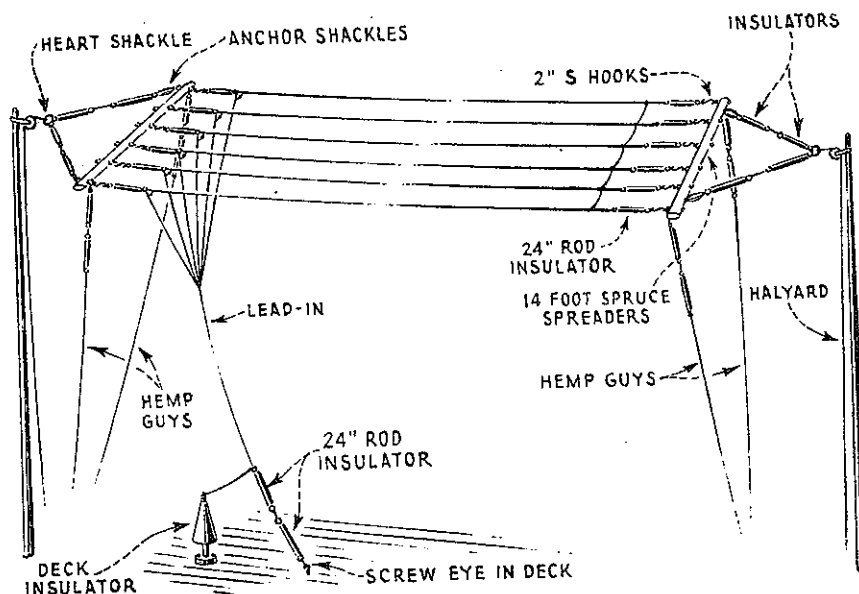


Figure 21

The lead-in wires are attached to one end of the flat top and fastened to the deck or cabin insulator. To remove the strain from this insulator, two hard rubber rod insulators are attached to the aerial and fastened to the deck by a wood screw as shown in the drawing. Positive connection is made between the lead-ins and the flat top by means of a McIntyre connector shown in Figure 22.

The general design shown in Figure 21 is not always duplicated in detail, but wherever possible it is adhered to.

The Deck Insulator. The transmitting aerial must be well insulated at the point where it enters the radio operating cabin by an insulator that will withstand at least 30,000 volts. One form of deck insulator is shown in Figure 23. A long hard rubber tube T about 2 inches in diameter has a brass rod extending through it which terminates at each end in a wire connecting lug, W. The tube is threaded at the center to take two wooden blocks, A, B, one of which is placed above the deck, the other underneath. After these blocks are drawn up tightly, the wood screws are inserted. To insure a watertight joint, a piece of canvas strip is placed underneath the blocks and thoroughly covered with white lead. A metal hood, H, fastened to the exposed end of the tube protects it from dampness.

A late type of deck insulator is shown in Figure 24, wherein a large electrose insulator has a heavy brass rod moulded securely into it which terminates at either end in a connecting lug. The outside of the insulator is threaded, and after it is inserted in the hole in the deck, it is drawn up tight by the collar, R, which is threaded on the inside. Other types of deck insulators are in use, but those just described are indicative of modern practice.

Installation of the Aerial. If possible a ship's aerial should be installed in such a way that the lead-ins will be free and clear of all mast, guys, or derrick booms. The further removed they are from parallel conductors of any kind, the less will be the danger of induced currents.

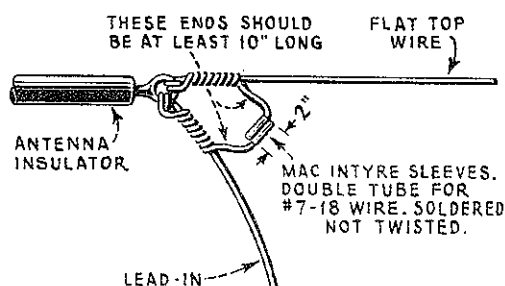


Figure 22

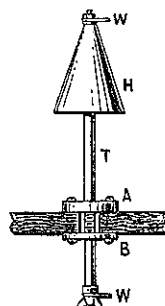


Figure 23

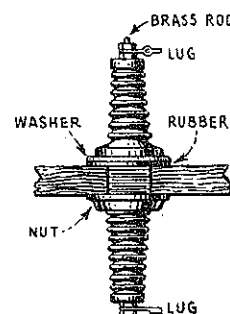


Figure 24

In measuring off the length of the flat top wires, approximately ten feet must be allowed at each end for the bridle, the insulators, and the reef block; hence 20 feet must be subtracted from the distance between masts. This can generally be obtained from the ship's plans or by actual measurement from mast to mast on the deck. Each wire is accurately measured between two points marked off on the deck and the wire cut and attached to the insulators. Six or eight inches must be allowed for serving the wire through the eye of the antenna insulator.

All connections are thoroughly made on the deck, after which the halyards are passed through the reef block and fastened to the shackle on the bridle. The aerial is then pulled into space, it being freed from all obstructions by three or more assistants.

Earth Connection. The connection from the transmitting apparatus to the earth plate should be direct as possible and the conductor should be one of high conductivity. In marine installations the earth wire is simply fastened to the metal bulkhead by a bolt, the earth connection being thus made through the hull. Usually this connection is not more than two or three feet long.

On wooden vessels connection is made to the propeller shaft in the engine room or to the water drip at the smoke funnels. Installations grounded or earthed in this manner generally do not transmit as far as those on vessels with steel hulls. Occasionally a wooden vessel is placed in drydock and 200 or 300 feet of copper or yellow metal nailed on the bottom for an earth capacity. A strip of copper is then led from it to the radio cabin.

The earth plate for the land station is sometimes very elaborate and may consist of a great number of copper or zinc plates buried in moist earth to a depth of several feet. In addition a number of wires are spread radially from the station in all directions, being laid particularly directly underneath the flat top portion of the aerial. If the station is located on rock or dry soil, the earth wires are merely laid on the surface of the ground underneath the aerial. All wires are then joined to a common terminal and connected to the apparatus in the station.

The earth plates and connections at the Radio Corporation trans-Atlantic stations are very elaborate and expensive. A number of zinc plates are laid in a circle of 100-foot radius, the transmitting station being situated at the center. About 250 copper cables connect from the transmitting apparatus to each of the zinc plates. A number of copper cables stretch out radially from the zinc plates, some of which lie directly underneath the aerial. In addition, a number of wires may be laid directly underneath the aerial on the surface of the ground. If the ground is particularly damp or marshy, modified arrangements may be used.

Type P-8 Panel Transmitter. As shown by the photographs, Figures 25, 26, 27 and 28, the P-8 transmitter consists of a transmitting panel on which are mounted the measuring instruments, a variable inductance, a fixed inductance, and a movable inductance, a spark gap and various switches and rheostats for controlling the wavelengths and power emitted by this transmitter. The motor generator is mounted on wood skids and is secured to the floor of the operating room back of the control panel. The starting and stopping resistance is mounted in a separate case which is provided with legs so that it may be fastened to the floor of the operating room behind and to the left of the motor generator. The transformer is immersed in oil in an iron case and is placed behind the motor generator and to the right of the starting and stopping resistance.

Two spark gaps are provided with this set. The quenched gap is mounted on a panel, which by means of hinges, can be swung open from either side. The rotary spark gap is mounted on the end of the motor generator. A switch is provided so that either gap can be used at will.

An automatic starter is provided which permits the motor generator to be started and stopped from any convenient place, such as the operating table. This automatic starter is so constructed that, when the generator is to be stopped, a resistance is connected across the motor terminals in such a manner that the motor generator is quickly brought to rest. An over-load relay is provided which opens the motor circuit when the current through it becomes excessive. This circuit remains open until the control switch is opened. It is then automatically closed so that the motor can be immediately started again when the control switch is closed, unless there is a permanent short-circuit on the line, in which case the relay will open again. This automatic starter mechanism the over-load relay and their appliances are mounted on a panel together with a D. C. line switch, a generator field switch and an A. C. line switch. Terminals are mounted for all wires running from this panel to other apparatus. These terminals are marked so as to designate their proper connections.

The motor generator consists of a 110 volt D. C. motor directly connected to a 500 cycle A. C. generator. The motor is so constructed that it will operate

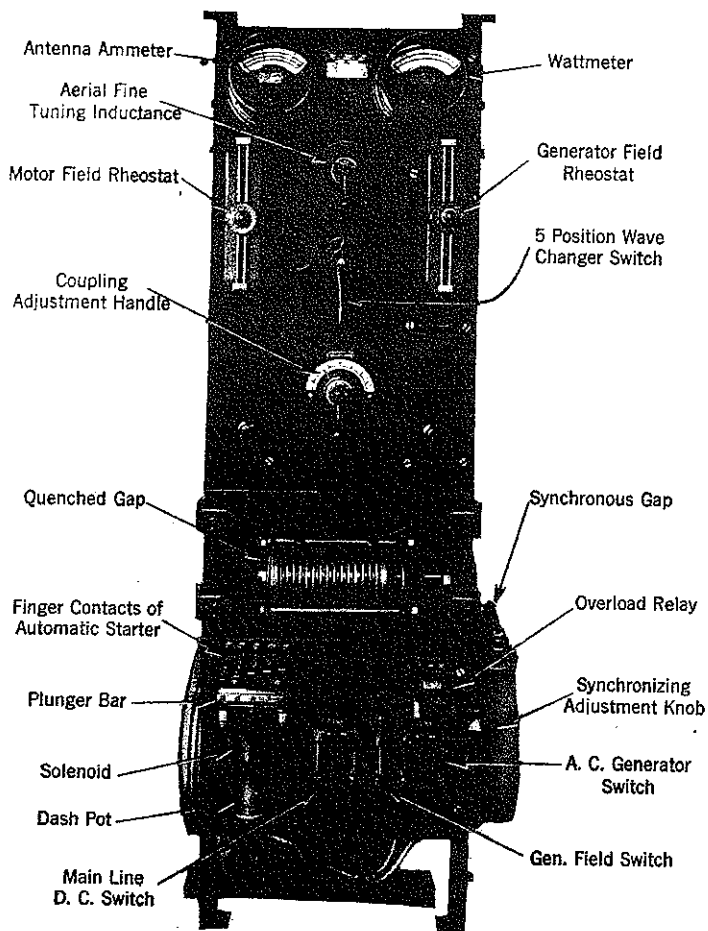


Figure 25

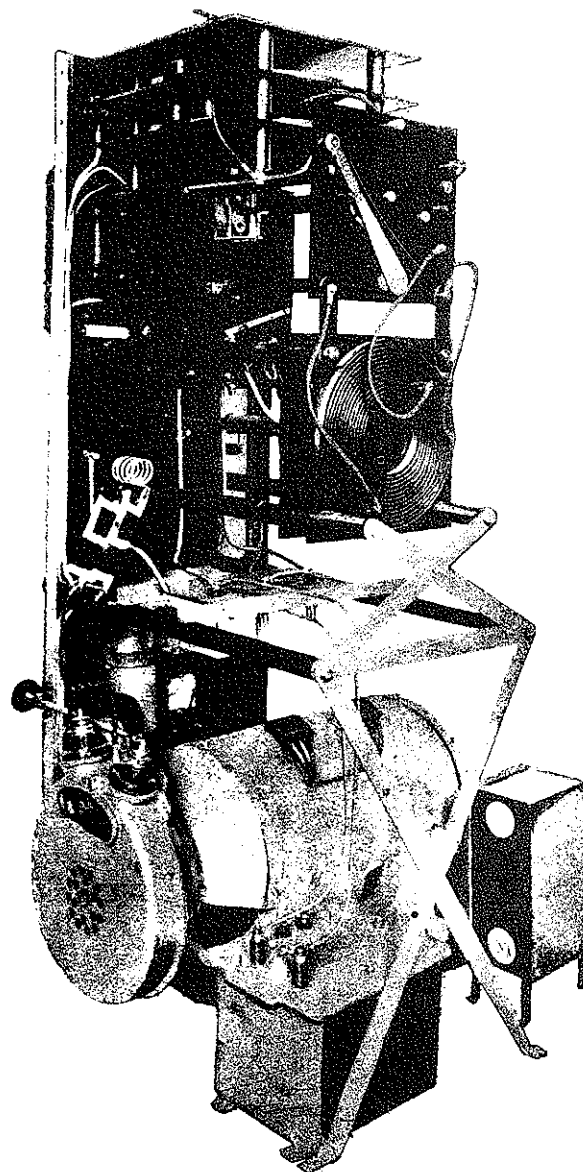


Figure 26

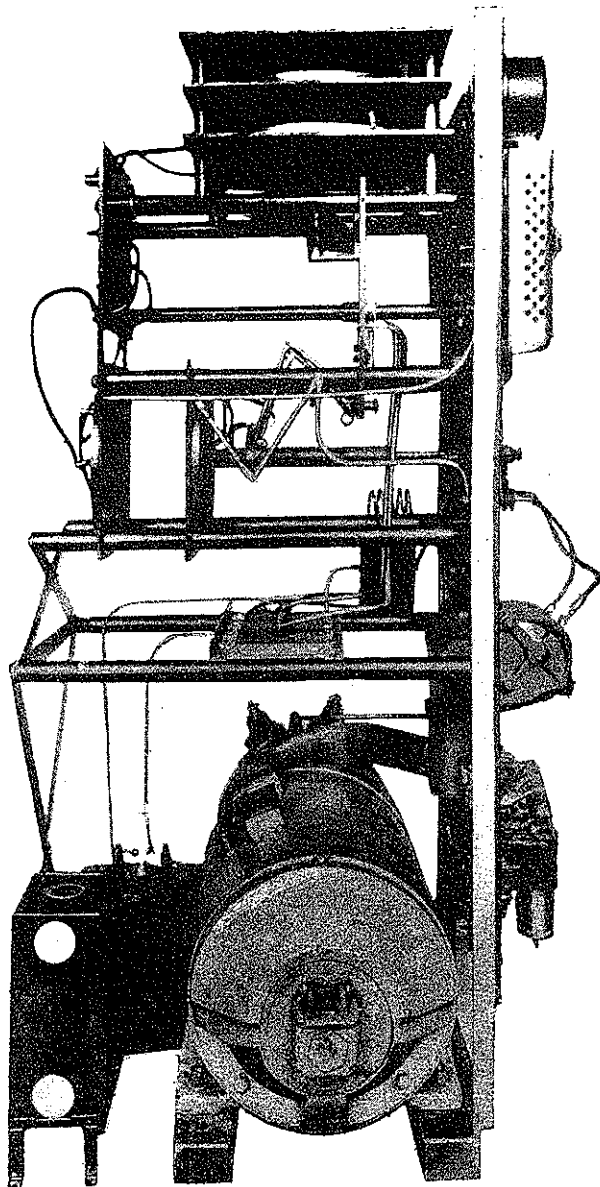


Figure 27

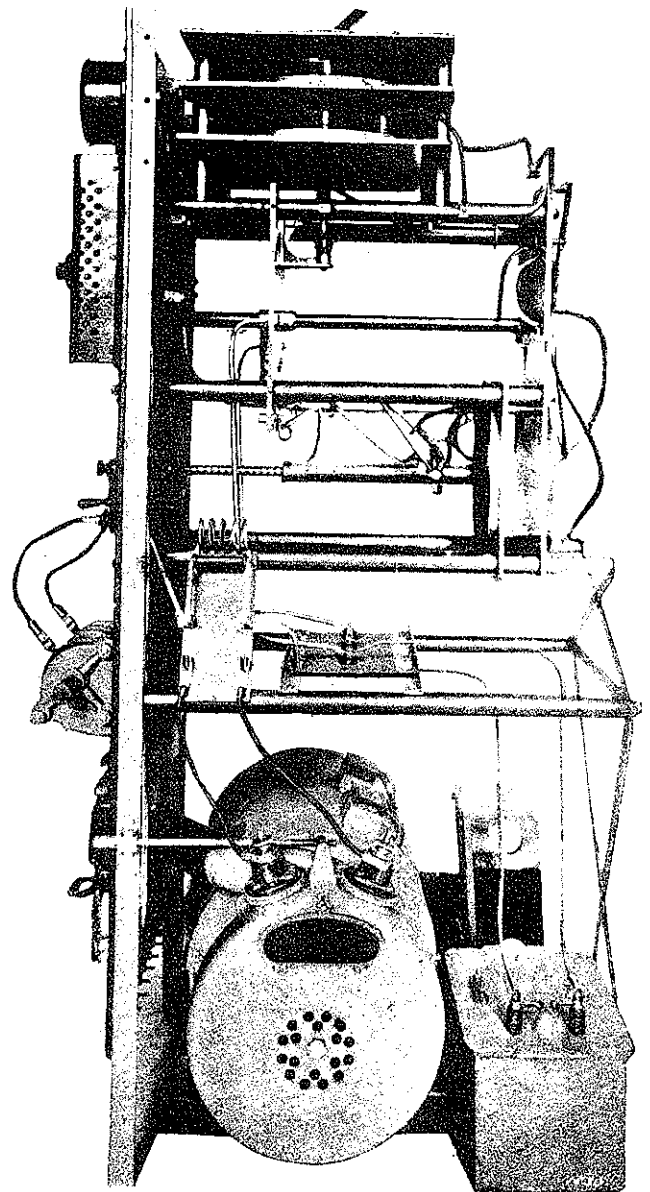


Figure 28

on voltages varying from 95 to 115 volts with very little variation of speed. A field rheostat is mounted on the transmitter panel for regulating the speed of this motor within narrow limits.

The generator is of the rotating armature type and has a normal open circuit voltage of approximately 350 volts and a working or load voltage of 140 volts. This voltage can be varied by means of a rheostat which is mounted on the transmitting panel. This rheostat is in series with the generator field and permits varying the current through the field, which is excited from the direct current line.

Condensers are provided for the purpose of protecting the motor and generator from excessive potentials caused by the operation of the transmitting apparatus. These condensers each have one of their terminals connected together and to the frame of the machine, the frame of the machine being connected to the ground. The other terminal of each condenser is connected to the terminal of the motor generator in such a manner that each terminal of the motor generator is connected to the ground through its respective condenser. The motor generator is connected to the control panel by means of lead covered wires in two groups, viz: the motor group and the generator group. The lead coverings of these wires are connected together and grounded to the machine and to the panel frame.

The transformer is of the closed core type and is immersed in non-liquid oil. The primary is connected to the control panel by means of lead covered wires which have their coverings grounded to the transformer case and to the panel frame. The secondary of the transformer is brought out through two insulators, on which the terminals are mounted. A protective spark gap is provided which permits a discharge when the potentials become excessive. This transformer is so constructed that it can be secured to the floor of the operating room back of the control panel. The secondary terminals of this transformer are connected to the terminals of the high potential condenser of the transmitting circuit.

The elements of the transmitting circuits, with the exception of the spark gap, are all mounted on insulators back of the transmitting panel and in such a manner that all changes or adjustments can be made by means of handles on the front of the panel. The transmitting circuits consist essentially of a closed oscillating circuit and an open or radiating circuit, known as the aerial circuit. These two circuits are inductively coupled. This coupling can be varied by means of a handle (marked coupling) mounted on the front of the panel.

The transmitting circuits are so constructed that five different wavelengths can be transmitted, viz: 600 meters, 706 meters, 750, 800 and 900 meters. The closed circuit consists of a high potential condenser so constructed that either half or all of its capacity can be thrown in circuit. The total capacity of this condenser is .012 mfd; mounted in a frame so that it can be easily removed and replaced. This condenser is mounted directly back of the quenched gap panel and it is necessary to swing this panel open when it is desired to remove or replace it. The change of wavelength is made by varying the amount of inductance in the closed oscillating circuit and also the amount of capacity. The switch handle marked "Wavelength" performs the function of varying the wavelength of the closed circuit and at the same time indicates the wavelength.

The open or aerial circuit consists of an inductance which is fixed relative to the panel. This is called the secondary and is connected in series with two other inductances, one of which is variable by means of the handle marked "aerial inductance" and the other (called loading inductance) is variable in any desired amount by means of contact clips. The outer end of the secondary inductance is connected to the earth through the antenna meter. Taps are taken off of this inductance at the necessary points, which, in turn, are connected to the wavelength switch. Another set of contacts are provided which connect with points on the loading coil of the aerial inductance. The inner terminal of this inductance is connected to the movable arm of the variable inductance. The outer terminal of the variable inductance is connected to the aerial circuit through the antenna switch. The object of these connections and the wavelength switch is to provide means for varying the amount of inductance in the aerial circuit and at the same time maintain the necessary coupling between the primary and secondary circuit without varying the distance between the two inductances. This permits changing the wavelength by throwing a single switch. This matter will be treated in detail later on under the heading "tuning the transmitter."

A changeover switch is provided in the closed oscillating or primary circuit which permits either the quenched gap or the rotary gap to be used at will. When the switch is thrown in position for using the rotary gap it is necessary to short-circuit the quenched gap. This is done by means of the clips which are connected to the same plate.

The radiation or antenna meter furnished with these sets is of the thermo type and consists of a wire heated by the antenna current which, in turn, heats a thermo-junction; this thermo-junction operates a direct current meter or indicating instrument. The heating wire is connected in series in the antenna circuit and the indicating ammeter is connected to this thermo-junction, which is contained in the ammeter.

A wattmeter is provided which indicates the power consumed in the transformer circuit. The current coil of this instrument is connected in series with the transformer primary and the potential coil across it.

To meet the Government requirements, provision is made for transmitting on low power. This is accomplished by throwing a fixed resistance in series with the field, which, in turn, reduces the potential of the generator. This is accomplished by opening the switch marked "low power" and at the same time, connecting in one gap only of the quenched gap. This low power condition cannot be obtained when using the rotary gap.

The foregoing is a general description of the apparatus and its object is to give a general idea of its type and functions. To better understand and operate this apparatus, it will be necessary to describe in detail the different parts as well as the method of tuning and manipulating them.

In Figure 29, "A" is the antenna ammeter, "B" is the wattmeter, "E" is the antenna inductance handle and indicator. The pointer indicates the number of turns inserted in the antenna variable inductance. A thumb nut at the center of this handle permits locking the same in any desired position. "C" is

the motor rheostat. "D" is the generator rheostat. "F" is the handle and indicator of the wavelength switch which varies the wavelength of the closed oscillating circuit, varies the wavelength of the antenna circuit and varies by fixed amounts the coupling between the two circuits. "G" is the handle and indicator for varying the coupling and indicating the amount. A thumb nut is also provided for locking this handle in any desired position. "H" are the quenched gap terminals and flexible leads. "J" is the quenched gap. "SS" is the screw for obtaining the necessary pressure on the gaskets of the gap. "II" are the hinges which permit the panel on which the gap is mounted to swing out so that the condenser may be removed. The pins of the hinges are removable so that the gap may be swung from either side. "M" is the automatic starter movement, which automatically cuts in the starting and stopping resistance. "N" is the over-load relay which opens the motor circuit when the current becomes excessive. The switch marked "D. C. Line" opens the feed line and disconnects the set entirely from its source of power. As the motor fields are permanently connected across the line when operating the set, this switch should be open when the set is not in operation, otherwise the motor field will be on continuously. The switch marked "A. C. Gen." should be open when any adjustments are made while the motor generator is running. It is well also to open the switch marked "Gen. Field" when making adjustments. "FF" is the motor generator which is mounted on the wood skids "MM". These skids keep the motor generator off the floor and also permit sliding it over the floor easily. "K" is the rotary spark gap. "O" is the handle which permits the rotation of the case together with the terminal "L". This is necessary to adjust the spark gap for proper phase relation. The proper adjustment of this gap is indicated by a smooth and uniform note.

Figure 30 is a side view of the transmitter showing the relative position of the different elements of the oscillating circuits and also the motor generator transformer, and starting and stopping resistance. "P" is a sliding contact which is rotated by means of handle "E" through the bevel gears "S". This contact slides along the spiral inductance "Q", cutting in or out any desired amount of inductance. "R" is another spiral inductance (called loading inductance) to which the adjustable contacts are connected. "RR" is a gear mechanism for rotating the pointer or indicator at "E". "V" is the contact arm which is moved by the handle "F". "U" is a plate of insulating material which carries a set of contacts for varying the wavelength of the antenna circuit and is controlled by the handle "F". "QQ" is a gear mechanism for operating the indicator "G". "Z" is a screw which causes "Y" to approach or recede from "X" by turning the handle "G". "Y" is the inductance in the closed oscillating circuit (called primary) and is in the form of a spiral. "AA" is the condenser rack which is mounted on insulating rods. "XX" is the change-over switch for changing from quenched gap to rotary gap. "CC" is the air duct for carrying the air to the quenched gap for the purpose of cooling it. The rotary gap "K" is so constructed as to act as a blower, which not only cools itself when it is operating as the spark gap, but also furnishes air for cooling the quenched gap. "L" are the terminals of the rotary gap which are connected to the lower terminals of the changeover switch. "BB" is a window which can be opened for inspection and adjustment of the rotary gap. This inspection window is for the purpose of inspecting the spark gap and making the necessary adjustments. The stationary terminals are mounted in porcelain insulators, which insulate each terminal from the casing. "TT" is a ground contact which

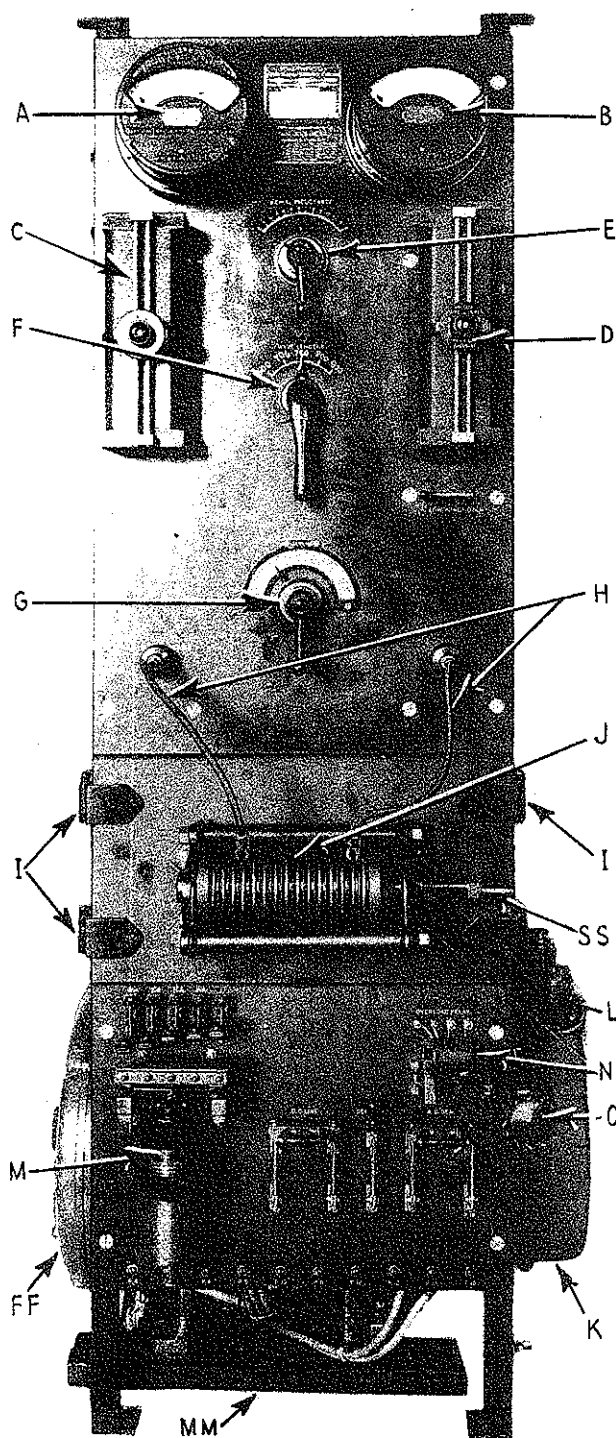


Figure 29

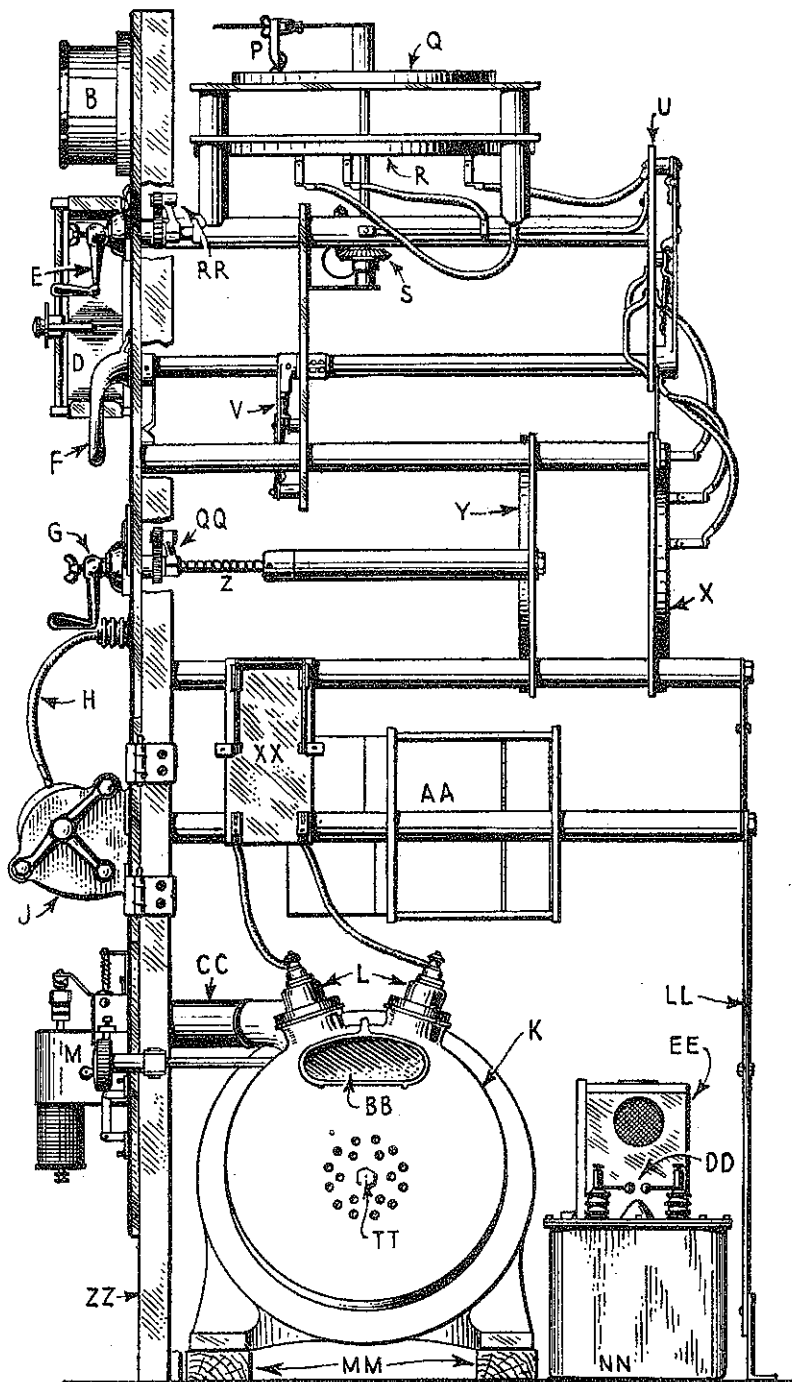


Figure 30

makes contact with the end of the motor generator shaft for the purpose of grounding it to "K", so that current will not flow through the bearings. "EE" is the starting and stopping resistance unit. "X" is the secondary or part of the inductance in the antenna circuit and is in form of spiral. "NN" is the transformer. "DD" is the protective gap of the transformer. "LL" is a brace for supporting the insulating rods carrying the different parts of the transmitting circuit. This brace has adjustable feet and should be carefully set so that there is not undue strain on the rods which they support.

Figure 31 is a front view of the starting panel showing the essential parts of the automatic starter and over-load relay. The resistance cut-out movement of this starter is operated by means of a solenoid, which is energized by the direct current of the line and controlled by means of a control switch.

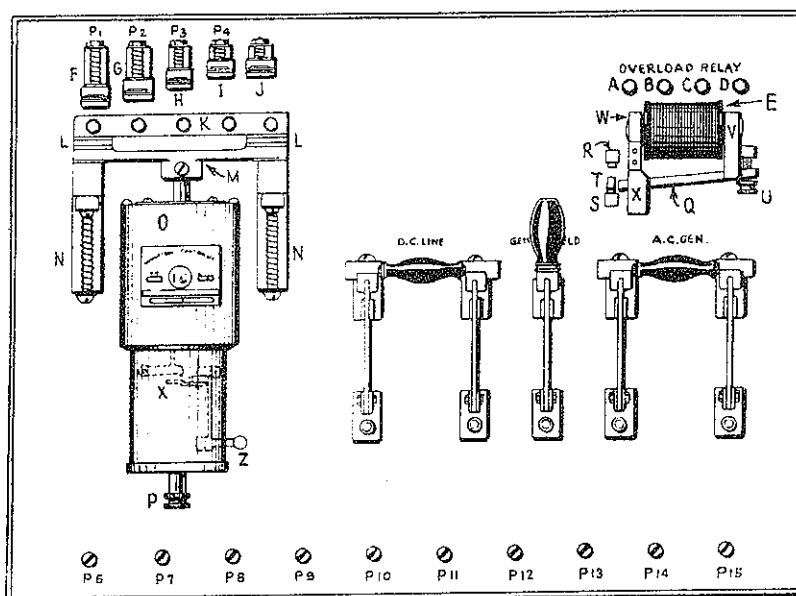


Figure 31

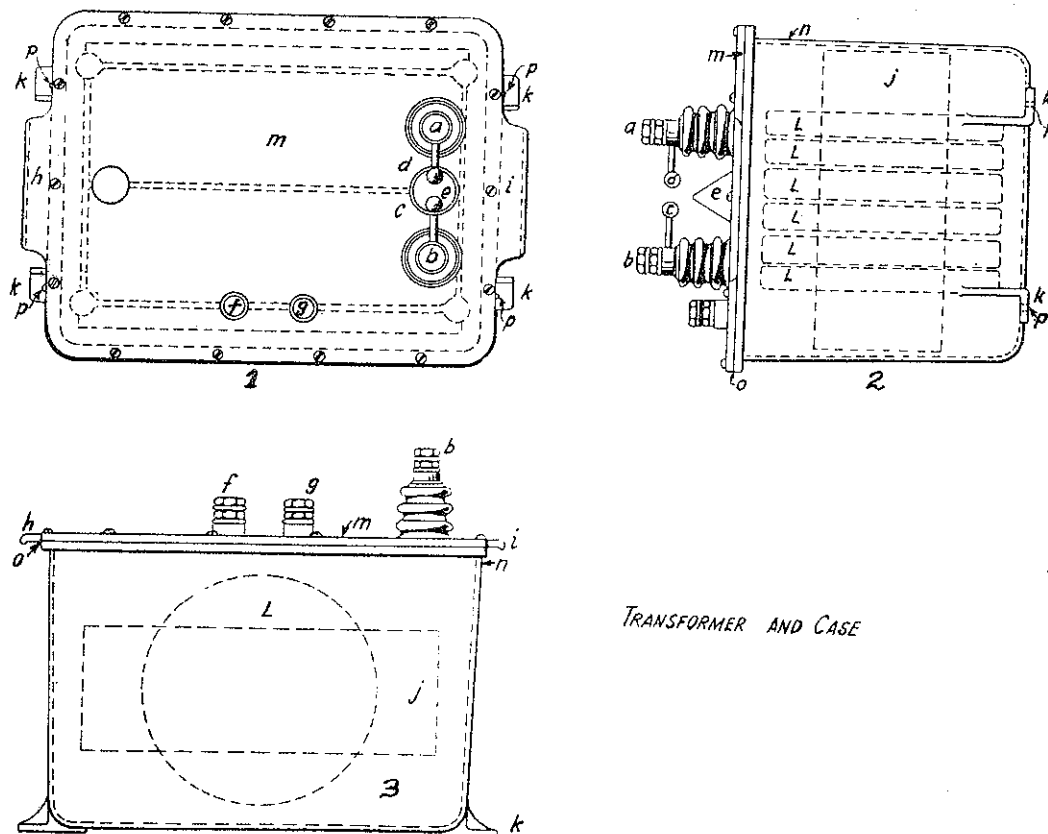
When the control switch is closed the solenoid is energized and moves a contact plate in a vertical direction so as to make contact at certain intervals of time with the contact arms. The speed of the motion is limited by means of a dash pot which can be adjusted, so as to properly time the cutting out of resistance. Contacts "F", "G", "H", and "I" are so adjusted that the contact plate "K" makes contact with them at certain predetermined times. "O" is the solenoid which is enclosed in a metal case. "K" is a contact which moves in vertical position when the solenoid "O" is energized. It first engages the contact "F" which closes the circuit through the armature of the motor, and through the starting resistance. After an interval of time it engages "G" and cuts out a portion of the starting resistance. It next engages "H" and cuts out another portion of resistance and finally it engages "I" and cuts out all of the starting resistance. Immediately after closing "I", it closes "J" which energizes the field of the generator. The field of the generator being open until the starting resistance is entirely cut out. This prevents operating the transmitter until the motor generator is up to full speed. The bar "M" is insulated from the bar "K" by insulator "L". This bar "M" is

so constructed that when the solenoid is not energized it connects the contacts "N" and "N". These contacts throw a resistance across the motor armature which brings the machine to a stop in a short period of time. The rate at which the contact plate "K" moves and consequently cuts out resistance is governed by the screw "P". This screw adjusts the admission of air into the dash pot under the solenoid. The proper time for the complete starting of the motor is approximately 12 seconds, therefore, the adjustment of "P" should be carefully made. There is also means for adjusting the time of contact between the contacts "F", "G", "H", "I", and "J". These adjustments are carefully made in the factory and should not need further adjustments unless they have been changed after leaving the factory. The contact "X" and "Z" which are situated between the panel and the dash pot are for the purpose of cutting a resistance in series with the solenoid "O" after the plate "K" has moved into final position. These should open one-eighth of an inch when "K" is in final position. It requires considerable energy or current flow to move the plate "K" against the upper contacts, but when "K" is in final position, it only requires a small amount of current to hold it; therefore, the series resistance is connected in at the proper time to prevent the solenoid from becoming overheated by the excessive current which would otherwise flow. Care should be taken to see that this contact opens at the proper time and also that the resistance across the contact is in working condition. If this resistance should become broken the plate "K" would tend to vibrate like an electric bell, as the circuit would then be opened as soon as the contact "K" opened.

The over-load relay consists of an electro-magnet having an armature which has its distance from the poles of the magnet adjustable so that for each adjustment a certain strength of current is necessary to lift it. This armature operates a contact which, when in the down position, closes the circuit through the solenoid "O" and when in the upper position, or after it has been lifted by the magnet, it engages the upper contact which closes a circuit through the holding winding, thus holding the lower contact open. When this lower contact is opened, the circuit through the starter solenoid is opened, and this causes the plate "K" to drop and open the circuit through the motor armature. As soon as the control switch is opened the armature of the relay drops and closes the circuit through the starter solenoid, but as this circuit is still open at the control switch, it is necessary to close the control switch again to start the motor generator. The coil "E" is composed of two windings. One is called a series coil and is in series with the motor armature so that all the motor current passes through it. When this current becomes excessive the armature "Q" is raised and the contact between "T" and "S" is broken. This in turn opens the circuit between "K" and "F". When the armature "Q" is raised, a contact is made between "T" and "R" which closes a circuit through the shunt winding on the magnet which holds up the armature "Q" until the control switch is opened. A plate "X" has a scale indicating the point to which the armature must be set for different values of current. The screw "U" regulates this position. The normal working position of this relay is for 40 amperes. When a short circuit or over-load occurs and this relay is operated, all that is necessary to re-start the machine is to open and close the control switch unless there is a permanent short-circuit on the line, in which case the relay will again open the circuit. The short-circuit must then be removed.

The shunt coil should be connected to "A" and "B" and the series coil to "C" and "D". If the terminals of the shunt coil should become reversed for any reason, the relay will not work properly. This condition will be indicated by the failure of the shunt coil to hold the armature up. When a short-circuit occurs the armature will vibrate slowly. If this occurs, the terminals of the shunt coil should be reversed at "A" and "B".

Figure 32 shows a side view, a top view, and end view of the transformer. Diagram 1, Figure 32, is a top view of the transformer. The top is held in place by a number of screws. A felt gasket is placed between the top of the



TRANSFORMER AND CASE

Figure 32

transformer and the casing for the purpose of packing same. "h" and "i" are handles by which the top may be lifted off when the holding screws are removed. The core with windings and all connections are secured to the top so that when it is removed they are removed with it. As the can is entirely filled with a non-liquid grease, it will be necessary to warm the transformer before removing the top. The grease is non-liquid at ordinary temperature, but when warmed up it becomes liquid. "a" and "b" are the secondary terminals to which the safety gaps "c" and "d" are attached. "e" is a projection of the lid which permits the discharge to take place to the casings when potentials become excessive. The casing of this transformer must be grounded. The secondary terminals "a" and "b" pass through the bushings in the cover which insulate them from the case. "f" and "g" are the primary terminals which are insulated from the cover "m". "k" and "k" are feet which have holes, "p", through them for securing the transformer to the floor of the operating room.

Diagram 2, Figure 32, is an end view of the transformer. The dotted lines represent the position of the core and the windings inside the case. The dotted rectangles marked L, L, L, etc. are the secondary coils. The dotted rectangles marked "j" is the core of the transformer.

In diagram 3, Figure 32, the dotted line shows the position of the core and coils inside the transformer. The dotted circle marked L is the outline of the secondary coil, while the rectangle "j" is the outline of the core. This core and winding are secured to the cover of the transformer.

Figure 33 shows a front view of the quenched gap partly in section. This gap consists of a number of copper discs or plates having parallel sparking surfaces, and separated from each other by means of paper rings specially treated with an insulating material. These plates are set in a trough in

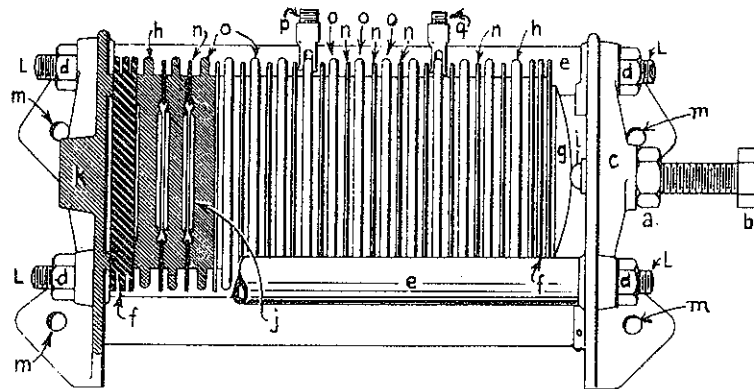


Figure 33

such a manner that they can be clamped together so as to make the enclosed space between the discs air-tight. In the drawing "b" is a screw which passes through the end bracket "c" and engages the plate "g". The nut "a" locks the screw in position. "k" is the other end bracket, the two end brackets being held together by means of the rods "l" and nuts "d". The rods "l" are covered by insulating tubes "e". These insulating tubes are so placed that they form a trough or support for the sparking plates and gaskets. "f" is a disc of insulating material which insulates the end plates from the brackets "k" and "c". Between the plates "o" and "o", etc., are placed the gaskets "n", "n", etc. "j" is the sparking face of the plate "o".

"p" and "q" are contact clips for connecting the gap in the oscillating circuit. In setting up this gap, care should be taken that the spark surfaces are absolutely clean and smooth. The paper discs or rings should also be clean. The gap should be set up as shown in the drawing. There are 15 plates, giving 14 spark gaps. The two end plates have only one sparking surface. When the gap is properly placed in the holder, the screw "a" should be set up hard with a 10 inch wrench. The gap is mounted on the panel by screws through the holes "m", "m", etc., in the end brackets.

If the gap is not air-tight, the note produced will be irregular. This is an indication that the gap is leaking and it should be therefore taken apart, the spark surfaces cleaned, and reassembled using new gaskets. The gap should not be used to any extent after it once starts to leak. This gap is cooled

by means of an air-blast brought in from the back of the panel through a duct which connects with the rotary spark gap and blower. The number of gaps may be adjusted by changing the position of the clips "p" and "q". In case one of the gaps should become defective, it can be short-circuited by means of a metal contactor, which is furnished for that purpose. The defective gap can be detected by means of a short-circuiting contact on an insulating handle (called test rod). The gaps can be successively short-circuited until the gap which is defective is short-circuited, after which the tone will become uniform. A permanent short-circuit can then be made on this particular gap. Sparking surfaces of the gap can be cleaned and smoothed up by means of a very fine sand paper. Care should be taken to keep the surfaces perfectly flat, so that the opposing surfaces are parallel. When the gap is in proper working condition the spark surfaces show a uniform coloring over the whole area. If the surfaces of the gap are black or dark colored, it is an indication that the gap is not properly seasoned. If the plates are rough, it is an indication that the gap is not air-tight. It requires a continuous running of from 1 to 2 hours to properly season the plates for this gap. The note will not be clear until the gap is seasoned.

Figure 34 shows the construction of the rotary spark gap and blower. This gap is contained in a cast iron base which is mounted on the generator end of the motor generator by means of four lugs cast on the bearing bracket of the machine. The back plate of the casting is screwed to these lugs by means of four screws. The casing is removable from this plate and may also be rotated on the plate, it being held by means of a ring. Diagram 1, Figure 34, is a front view of the complete gap and blower. The dotted lines show the rotating disc, or rotor and blades; and the arrow the direction of rotation. "d" and "e" are adjusting nuts which permit the stationary electrodes to be moved in a radical direction.

Diagram 2, Figure 34, is a section of the gap showing the method of mounting the rotor on the shaft and also the method of mounting the casing on the generator. "e" is the adjusting nut for adjusting the stationary electrodes. "c" is a thumb nut for clamping the inspection window in place. "b" is a red glass plate which permits viewing the spark during operation. "i" and "i" represent the space between the blades carried on the rotor and the casing. This space should be one-sixteenth of an inch. Care must be exercised when setting this rotor to see that the end play of the shaft does not exceed one-thirty-second of an inch. Means for adjusting this end play will be described later. "v" and "v" are the studs on the bearing bracket of the motor generator and support the plate "w". "k" is the casing which is rotatable around the plate "w" and secured to same by means of clamps "g". The clamps are secured to the casing "k" by means of screws. When the screws are removed, the casing can be removed. "f" shows the spark terminals carried on the rotor by means of studs which pass in a radial direction, through the rim of the rotor and are held securely by lock nuts. "h" and "h" are the blades of the rotor which take the air from the center of the casing through a number of holes and force it to the upper space of the casing, where it passes through a port and duct to the quenched gap. "a" is a nut carrying a contact which engages the center of the shaft "s". This is for the purpose of grounding the shaft directly to the case and under no circumstances must the set be operated without this contact in proper position. A little oil should be applied to the point of this contact about once each week.

Diagram 3, Figure 34, is a back view of the rotary gap showing the upper portion in section. "d" and "e" are the adjusting nuts which engage in a thread in the studs "l". This permits the adjustment of the stud in a radial direction. This stud is carried in the bushing "p". A spring is inserted in the center of the rotor. "r" is a nut which clamps the bushing in the flexible lead and makes the necessary contact. "f" is the spark point on the rotor and "j" is

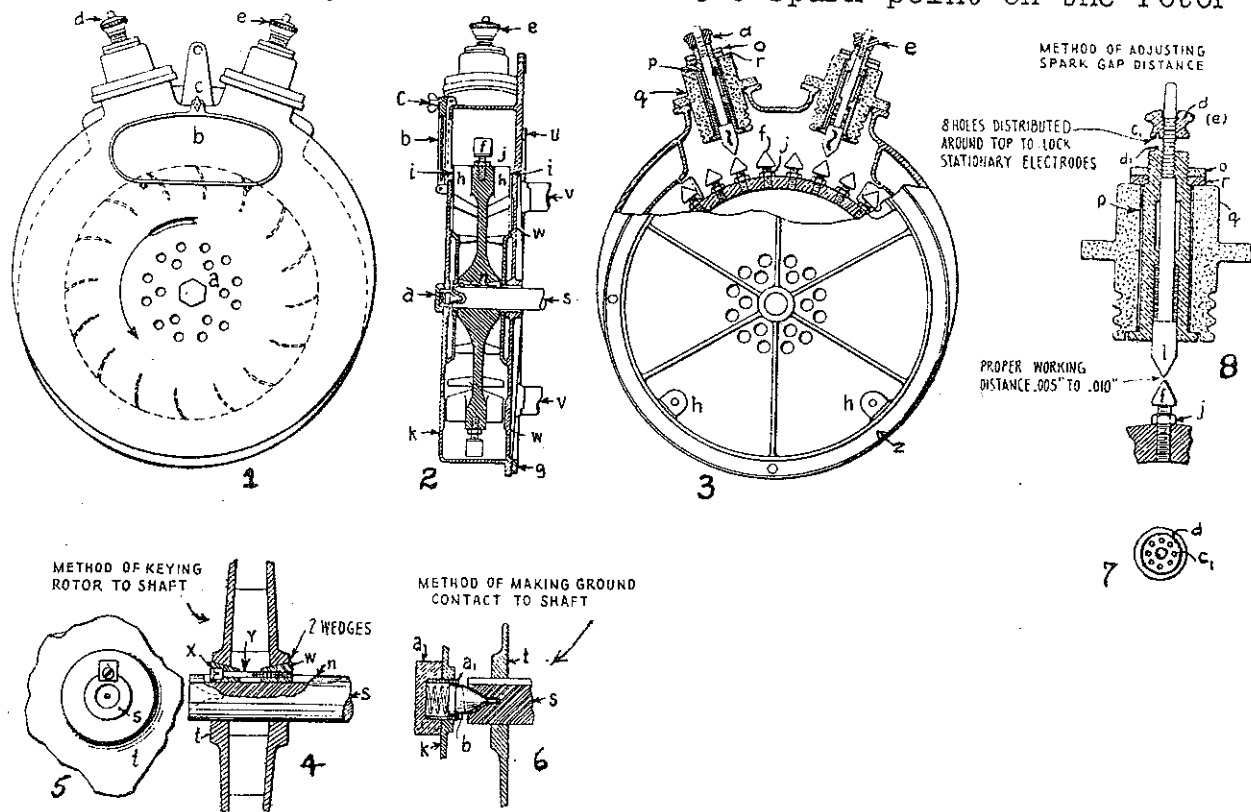


Figure 34

is the locking nut. "j" is stud housing. "z" is a ring which holds the casing to the back plate. "h" and "h" are the bosses which engage the studs which hold the casing to the motor generator frame.

Diagram 4, Figure 34, shows the details and method of keying the rotor to the shaft. "s" is the shaft of the motor generator. "n" is the keyway in the shaft "s". "w" is a wedge shaped key having a threaded hole through it so as to engage the screw "y". "x" is another wedge shaped key which is counter bored so as to engage the head of the screw "y". When the rotor is put in proper position, the screw "y" is turned up until the wedges securely clamp the rotor to the shaft "s".

Diagram 5, Figure 34, shows a front view of the rotor "t", shaft "s" and key "x". To remove the rotor from the shaft, all that is necessary is to turn the screw out until its head is exposed, when a slight tap of the hammer handle or any hard piece of wood will loosen the wedge "w". As soon as this wedge "w" is loosened, a slight tap on the hub of the rotor will loosen the wedge "x" so that the rotor may be easily removed.

Diagram 6, Figure 34, shows in greater detail the ground contact at the end of the shaft "s". "A1" is a brass collar threaded on the outside so as to engage a thread in the casing "k". This collar passes into the nut by means of the same thread. The steel point "b" is retained in this collar and held in place by means of a spring. The point of "b" should make good contact in the exact center of the shaft "s".

Diagram 7, Figure 34, is a section of the stationary spark gap terminal and the rotating terminals. "d" is the adjusting nut which has eight holes bored in the under surface and equally spaced around the center. C-1 represents one of these holes which engages in the pin D-1 so that this nut cannot be rotated until it is lifted out of the engagement with the pin.

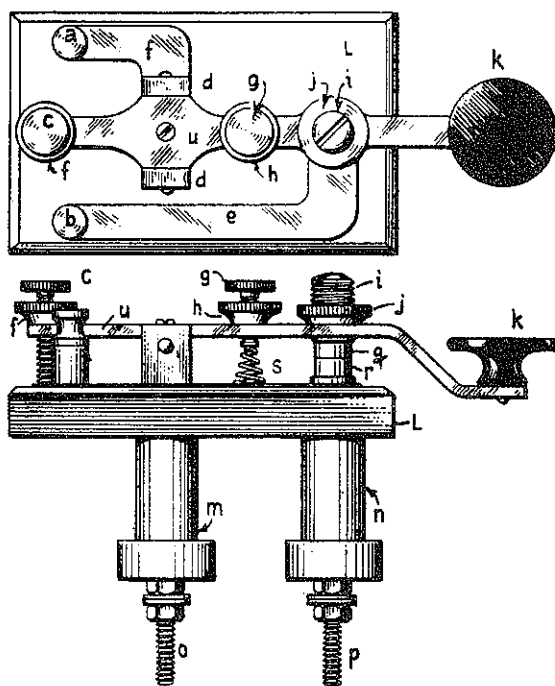


Figure 35

Diagram 8, Figure 34, shows the under face of this nut and the position of the holes. Each turn of the nut represents a radial movement of .037 of an inch, and as there are eight holes equally spaced in the face of the nut, the movement of one hole represents a radial movement of approximately .005 of an inch. In adjusting the distance between spark points *l* and *f*, it is necessary to use great care and this adjustment should never be made while the machine is running. The tips of the rotating points are all trued to the center of the rotor therefore if the spark terminal *l* is adjusted so as to just touch the rotor, then the number of holes which the nut makes in the turning will be a measure of the distance between the spark points *l* and *f*. The proper working distance for this gap is between .005 inch and .010 inch. The gap should not be set less than .005 inch or over .010 inch. After the gap has been set to the proper working distance the set should then be started and the gap adjusted by means of the handle "o". This adjustment is an angular one and brings the spark points "l" and "f" to maximum. If the gap does not have the proper angular position, the electrodes will not be in proper phase relation with the generator voltage.

Figure 35 is a top and side view of the type "C" key. "a" and "b" are the terminals of the key to which the connections can be made. "u" is a lever which is pivoted in the supports "d" and "d". "c" is a screw which allows adjustment of the lever "u" in a downward position. "g" is a screw which permits adjustment of the spring "s" on the lever "u". "h" is a nut for locking the screw in position. "i" is a screw which passes through the lever "u" and carries the silver contact "q" which engages a fixed contact "i" mounted on the base of the key. The screw "i" should be adjusted so that the contact faces of "q" and "r" are exactly parallel when in contact. It should then be secured by means of nut "j" in this position. The screw "c" should then

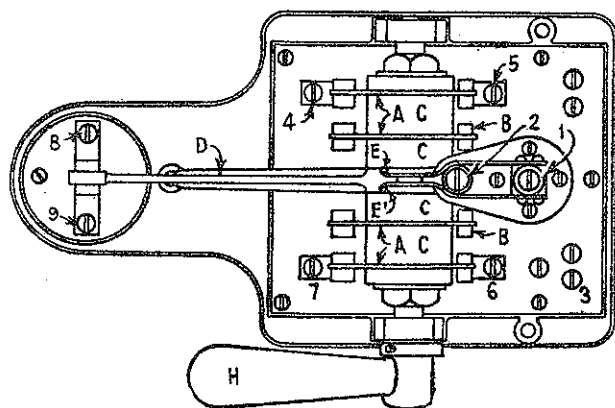


Figure 36

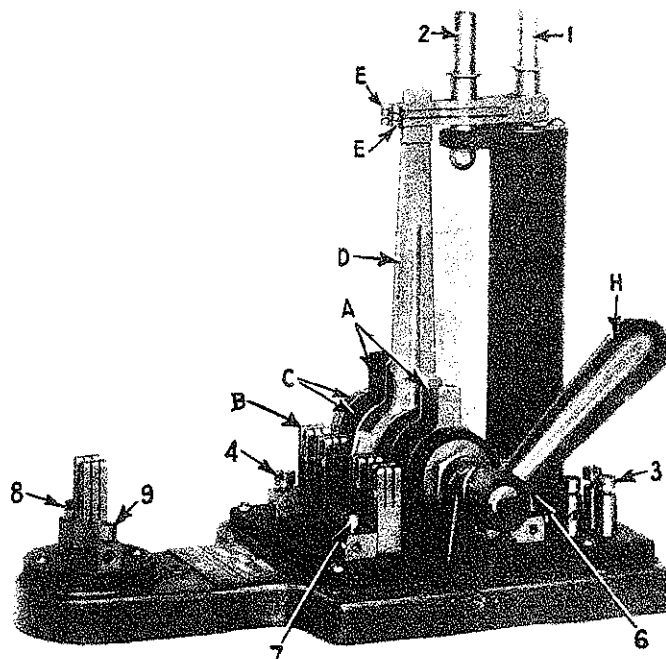
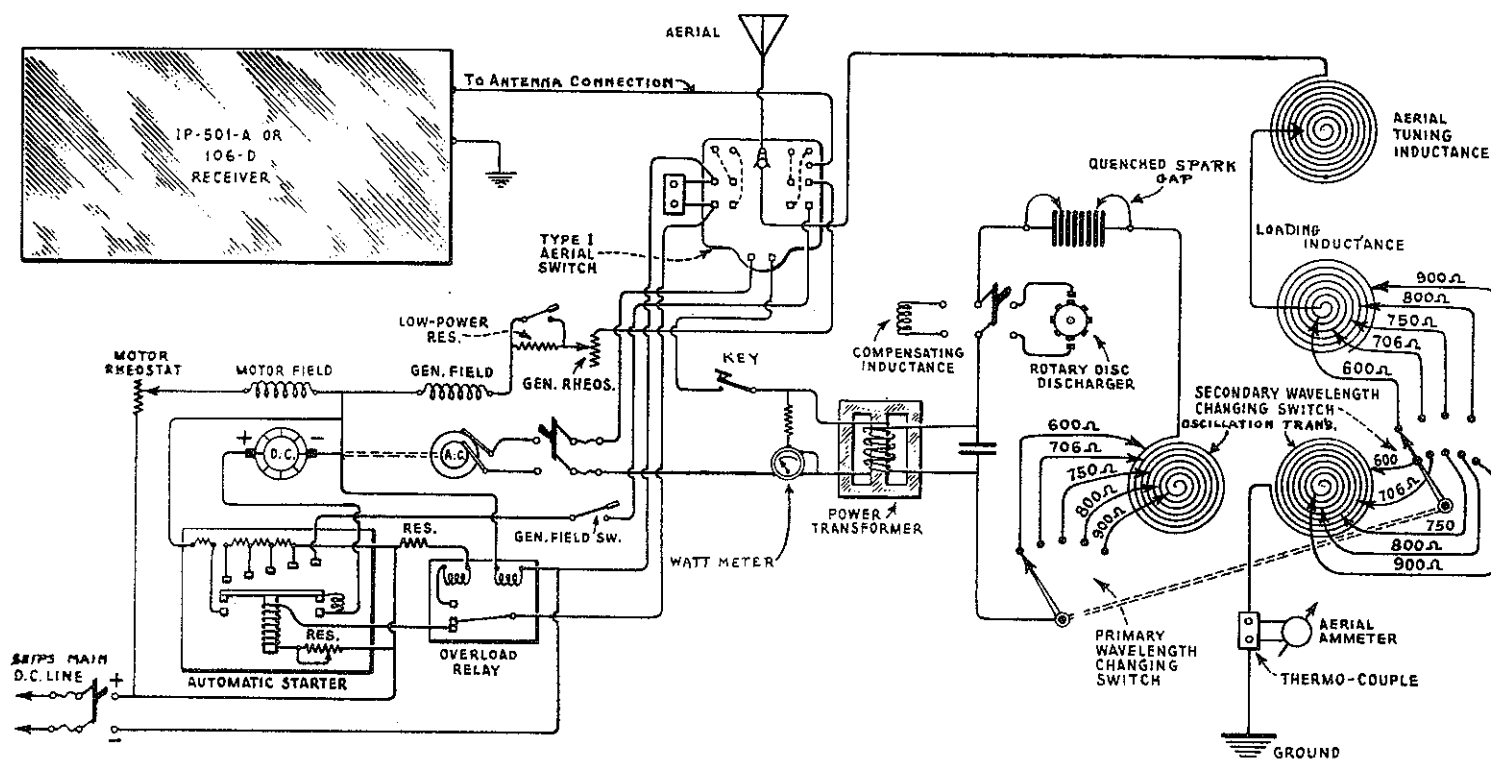


Figure 36A

be adjusted to allow the necessary movement for opening the contact. The pressure of the spring "s" should then be adjusted by the screw "g" until the desired amount is obtained. "k" is a knob by which the key is manipulated. "l" is the base of the key which is secured to the operating table. The legs "o" and "p" pass through the top of the operating table through the bushings "m" and "n".

The Aerial Change-over Switch. A plan view and side elevation of this switch is shown in Figures 36 and 36A. Several steel discs, "A", which make connection with the spring contacts "B" on either side of the rod, are mounted on a hard rubber rod "C". When the handle "H" is thrown downward a long steel bar "D" closes the circuit to the primary winding of the power transformer through the contacts "8" and "9". When this bar "D" is thrown in the opposite position it separates the spring contacts "E" and "E", disconnecting the transmitting oscillation transformer from the aerial during the period of reception.



Complete circuit diagram of the P-8 Spark Transmitter

The connections shown are described as follows:

- (1) Connects to the aerial.
- (2) Connects to the aerial oscillation transformer tuning inductance.
- (3) Connects to the receiver antenna post.
- (4-5) Connects to remote control button when used.
- (6-7) Connects to generator field.
- (8-9) Connects to the a.c. generator line.

EXAMINATION - LESSON 57

1. Describe the oscillatory discharge of condenser in a transmitting circuit.
2. What is meant by the term, "Logarithmic Decrement?"
3. Where is the ground connection usually made on ship-board?
4. What purpose does the quenched gap serve?
5. What is a feebly damped wave?
6. Why are protective condensers used on a motor generator?
7. What is an "aerial inductance?"
8. Name the most important parts of a spark transmitter.
9. What is the purpose of the aerial change-over switch?
10. What type antenna is best suited for ship-board use when a spark transmission is employed?